THE UNIVERSITY OF ALBERTA

EFFECTS OF UNCONDITIONED STIMULUS INTENSITY AND SCHEDULE OF PARTIAL REINFORCEMENT IN HUMAN CLASSICAL EYELID CONDITIONING

by

© DENNIS LARRY FOTH

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "Effects of Unconditioned Stimulus Intensity and Schedule of Partial Reinforcement in Human Classical Eyelid Conditioning", submitted by Dennis Larry Foth in partial fulfilment of the requirements for the degree of Master of Science.

of performance than did the strong UCS intensity but this difference, however, was not statistically significant. No difference in latency distributions were obtained with all groups giving the greatest frequency of CRs 350-400 msec after CS onset.

The findings were interpreted in terms of a two-contingency model of classical conditioning. This model hypothesized that the effects of UCS intensity were due, not to the level of drive, but to the instrumental contingency [R-UCS(offset)] which modifies the response given that conditioning occurs through the classical contingency [CS-UCS(onset)]. Generalized drive theory, as currently formulated, could not adequately explain the results of this study.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

Introduction

A concept that has been extremely important in human classical conditioning theory is that of generalized drive. This concept has been developed by Spence (1956, 1958) from basic Hullian theory to account for differences in performance in classical eyelid conditioning that have been obtained when different UCS intensities have been employed as an independent variable. With the exception of some early studies using patterned reinforcement, the relation between UCS intensity and eyelid conditioning performance has been found to be monotonic; that is, the greater the intensity of the air-puff UCS, the higher the level of performance. However, some recent theoretical considerations and research indicate that the generalized drive concept has limited application when a combination of variables, such as UCS intensity and schedule of reinforcement, are employed.

This thesis is concerned with the applicability of the generalized drive concept to human classical eyelid conditioning. A theoretical model is proposed whereby the results of this study, those studies currently inconsistent with the generalized drive concept, and previous eyelid conditioning studies might be explained.

The Concept of Generalized Drive

Spence's theory of conditioning (Spence, 1956) makes use of the

Hullian postulate that $\underline{E}$, an excitatory potential which determines the strength of a response, is a multiplicative function of $\underline{D}$, a generalized drive factor, and $\underline{H}$, a learning factor sometimes referred to as habit strength.

Spence (1958) assumed that $\underline{D}$ was a positive function of a hypothetical emotional response, $\underline{r}_e$, which was aroused in the organism by some sort of aversive stimulation and which persisted in the presence of this kind of stimulation. By increasing the amount of this aversive stimulation, it was assumed that $\underline{r}_e$ was increased which consequently led to an increase in $\underline{D}$. According to the Hullian notion, an increase in $\underline{D}$ should lead to an increase in $\underline{E}$ ($\underline{E} = \underline{D} \times \underline{H}$) which Spence operationally defined as a function of the frequency of conditioned responses (CRs) emitted by the organism. Given the same intensity of aversive stimulation, Spence also felt that individuals differed with respect to the magnitude of $\underline{r}_e$ that such stressful stimuli evoked (Spence and Taylor, 1951; Spence, 1958). It was this assumption and subsequent attempts to measure it which led to the development of the Taylor Manifest Anxiety Scale (Taylor, 1951). Hence, high and low drive could be defined in two ways: by extreme scores on the Taylor Manifest Anxiety Scale (MA) and by the intensity level of the UCS. Upon reviewing the human conditioning studies prior to 1958, Spence concluded that the evidence clearly showed that the higher the $\underline{D}$, the greater was the mean level of performance. The following studies are predominantly concerned with intensity of the UCS as the operational definition of drive rather

than the MA scores.

In terms of the UCS intensities used in the following studies, some are reported in pounds per square inch (psi) while others are reported in millimeters of mercury (mm of Hg). For purposes of comparison a UCS intensity of one psi corresponds approximately to a UCS intensity sufficient to support a 50 mm column of Hg. UCS intensities have ranged from .25 psi (12.5 mm of Hg) to 5.00 psi (250 mm of Hg). A weak UCS intensity is generally less than 2 psi (100 mm of Hg) while a strong UCS intensity is generally 3 psi (150 mm of Hg) or greater.

UCS Intensity Studies: Continuous Reinforcement

Although Pavlov (1927) manipulated hunger to vary the intensity of the UCS he employed in his salivary conditioning studies, it was not until 1948 that motivational factors in classical conditioning were systematically subjected to experimental investigation in North America. The first study which investigated the effects of UCS intensity upon human eyelid conditioning was carried out by Passey (1948). Passey employed four different UCS intensities and found that the response frequency for the last block of five acquisition trials was greatest for the strongest UCS intensity condition (100% CRs) and smallest for the weakest UCS intensity condition (70% CRs). He concluded that the level of eyelid conditioning performance

approximated a logarithmic function of the intensity of the UCS. More recent studies which have supported a monotonic relationship between performance level and UCS intensity are the following: Beck (1963), Prokasy, Grant and Myers (1958), Ross and Hunter (1959), Spence (1953), Spence, Haggard, and Ross (1958), Spence and Taylor (1951), and Walker (1960). Three major conclusions have been made from these studies involving UCS intensity and continuous reinforcement (Beecroft, 1966). The first is that the level of performance is some monotonic function of the intensity of the UCS. Second, the relationship between performance and intensity of the UCS is negatively accelerated and rises sharply over low UCS intensity values. Finally, intensity of the UCS affects asymptotic performance rather than the rate of acquisition.

UCS Intensity Studies: Partial Reinforcement

Ross and Spence (1960) compared data from a number of studies previously run at the Iowa laboratory under highly similar experimental conditions to investigate the effects of UCS intensity in eyelid conditioning under random 50% partial reinforcement. They concluded that continuously reinforced eyelid conditioning was a negatively accelerated function of UCS intensity and that under a 50% partial reinforcement schedule conditioning performance resulted in an S-shaped curve with little performance change over low UCS intensities (0.3 - 1.0 psi). However, some

inconsistencies exist with respect to this finding.

The first suggestion that the relationship between eyelid conditioning performance and UCS intensity might not be monotonic under partial reinforcement has been made by Runquist (1963). A group that had been conditioned with a weak UCS intensity under a random 50% partial reinforcement schedule attained a slightly greater level of asymptotic performance than did its strong UCS intensity counterpart. That is, conditioning performance was inversely related to UCS intensity under a schedule of 50% partial reinforcement. To account for this finding Runquist suggested, on the basis of an analysis of trials following a nonreinforced trial, that nonreinforcement produced more inhibition when the UCS intensity was stronger.

A result consistent with that of Runquist has been obtained by Boice and Boice (1966). They found that, for two groups using a random 50% partial reinforcement schedule, the group conditioned with the weaker UCS intensity performed significantly better than did the group conditioned with the stronger UCS intensity.

A procedural difference concerning nonreinforced trials exists between the Ross and Spence (1960) and the Runquist (1963) and the Boice and Boice (1966) investigations. Ross and Spence used a 2500 msec delayed UCS as an instance of a nonreinforced trial whereas Runquist and Boice and Boice omitted the UCS on nonreinforced trials. This delayed UCS procedure was instituted

by McAllister (1953) and involved lengthening the CS-UCS interval to a period where little or no conditioning occurred. The purpose of the procedure was to maintain D level without noticeably influencing H. The literature on the omission versus delay of UCS as an instance of a nonreinforced trial is conflicting (Spence, Rutledge and Talbot, 1963; Moore and Gormezano, 1963; Lockard, Lockard, and Grant, 1964) but its primary effect seems to be on performance during extinction trials (McAllister, 1953; Reynolds, 1958) and not on acquisition or asymptotic level performance. For this reason, the procedural difference between these studies is probably only minimally responsible for the discrepant findings.

A study reported by Gormezano, Moore, and Deaux (1962) also supports the possibility of inferior performance to the stronger UCS intensity in a partial reinforcement schedule. Using a yoked-comparison technique in which a S (yoked-control S) received a UCS to a CS only if another S (matched avoidance S) failed to give a CR to the CS, they found that the yoked-control Ss in the strongest UCS intensity condition performed more poorly than the two groups which received weaker UCS intensities. This finding, however, is questionable because the strongest UCS intensities elicited more CRs relative to the weak UCS intensity in the matched avoidance Ss which in turn reduced the number of UCS presentations to the CS for the yoked-control Ss under these UCS intensity conditions. Hence, the nature of the schedule of partial reinforcement for the

yoked-control Ss is determined by the frequency and pattern of avoidance responses made by the Ss in the avoidance condition.

In consideration of Spence's (1956, 1958) theory of generalized drive Prokasy (1967) has suggested that the function between D and H might not be multiplicative at all. He found, upon surveying the literature, that there is a general failure to support multiple predictions which would be made from the theory. An example is divergence between groups across trials.

A further criticism of Spence's theory has been made by Burstein (1965). Burstein has argued that there is no evidence to warrant Spence's (1953, 1956) conclusions about the effects of UCS intensity upon eyelid conditioning since Spence included data from nonconditioners in his investigations. Burstein concluded that UCS intensity has no significant effect when nonconditioners are excluded from the data and only determines whether or not an S will condition. Spence and Platt (1966) reanalyzed many of their previous studies with and without nonconditioners and found that the results of these studies did not change appreciably. Burstein (1967) then suggested that Spence and Platt (1966) had not used the Burstein (1965) criterion for defining a nonconditioner. Suboski (1967) used Burstein's (1965) criterion in evaluation of his investigations and found effects of UCS intensity on performance and has, as it appears, settled the controversy between Spence and Burstein.

In summary, investigations of UCS intensity in the continuously

reinforced eyelid conditioning situation have consistently demonstrated a superior level of conditioning for groups conditioned with the stronger UCS intensities. This fact has been interpreted as reflecting an increase in generalized drive to the higher UCS intensities. However, inconsistencies exist in the literature when random partial reinforcement schedules and UCS intensity have been investigated.

Random Partial Reinforcement Studies

Relatively few studies have been undertaken with the express purpose of investigating the effects of random partial reinforcement in classical defense conditioning of the human eyelid response. Most studies have used a 50% random reinforcement schedule to compare with a continuous control group with the exception of Froseth and Grant (1961), Grant and Schipper (1952), and Hartman and Grant (1960) who varied the percentage of reinforced trials. Each of the following studies used only one UCS intensity and, where these intensities have been reported, varied from 100 mm to 180 mm of Hg.

Humphreys (1939) was the first to compare a 50% partial reinforcement group and a continuously reinforced group in eyelid conditioning. He found that no difference existed between the partial and continuous groups. Humphreys used a very short CS-UCS interval of 400 msec and, as Grant and Hake (1951) pointed out, sensitized "Beta" responses (reflex blinks to the CS

sensitized by dark adaptation) occurring in the first 200 msec following CS onset may have been included in the data. Grant, Riopelle, and Hake (1950) replicated Humphreys' study and found that a 75% partial reinforcement group resulted in superior performance on the first day of conditioning than did the continuously reinforced group. They also found, however, that the continuous group gave more CRs than did a 50% partial reinforcement group. Ross (1959) suggested that the negative finding obtained between the 75% partial group and the continuous group might have been due to the fact that they used response magnitude rather than CR frequency as their behavioral measure.

Studies indicating a lower level of CR acquisition on random 50% partial reinforcement schedules as compared to continuous reinforcement have been published by Hartman and Grant (1960), Hartman and Grant (1962), Moore and Gormezano (1963), Reynolds (1958), and Ross (1959).

Reynolds (1958) in attempting to account for the inferior performance obtained under partial reinforcement as compared with continuous reinforcement suggested the presence of some inhibitory factor in the partial reinforcement group presumably developing as a function of nonreinforcements. This concept has been further developed by Ross (1959) in one of the more definitive studies concerning the effect of CR acquisition in eyelid conditioning. Ross was concerned with the nature of asymptotic performance on a partial reinforcement schedule because previous studies had

been more concerned with extinction and had run a limited number of acquisition trials. Ross ran five groups: continuous, partial, continuous for 100 trials and then switch to partial, continuous for 20 trials and then switch to partial, partial for 40 trials and then switch to continuous. All partial groups used 50% partial reinforcement and a nonreinforced trial consisted of a CS-UCS interval of 2400 msec. Ross found that a continuous reinforcement schedule produced a higher level of performance than a 50% partial reinforcement schedule on either a total trials basis or when the number of reinforced trials was equated for the continuous and partial groups. He also showed that switching from continuous to partial reinforcement after 100 trials resulted in an immediate response decrement to the level of responding of the partial group. However, the switch after 20 trials resulted in a relatively stabilized performance until the partial group reached the same level and then both groups increased at the same rate. Switching from partial to continuous reinforcement after 40 trials resulted in an increase in responding to that of the continuous group. Ross concluded that the inferior level of responding of the partial groups was due to the presence of some kind of decremental factor resulting from nonreinforced trials. He further concluded that the dissipation of this inhibitory factor was much slower than its acquisition.

The nature of this inhibitory factor has not been fully explained although Kimble (1967) reports an experiment by Fowler

(1964) which is instructive. Fowler found that a partial schedule of reinforcement had a more serious detrimental effect when the CS-UCS interval was long rather than short. Fowler used 4 groups in a 2 x 2 factorial design with factors being 50% and 100% reinforcement and .4 sec and 1.1 sec interstimulus intervals (ISI) respectively. The partial group using a 1.1 sec ISI asymptoted at about 12% CRs whereas the other three groups asymptoted at greater than 40% CRs. To account for these results Kimble suggested that three components might be involved which lead to the particular set that the Ss adopt towards the experimental situation: a cognitive component (nature of the CS, UCS; how they are paired), an emotional component (harmlessness or noxiousness of the stimuli), and the motivational component (how the S decides to react to the situation). In the Fowler study, the long ISI presumably allowed for the mobilization of the motivational component and caused the Ss to actively resist responding prior to the presentation of the UCS.

In summary, the findings reported by Boice and Boice (1966), Fowler (1964), and Runquist (1963) suggest that under conditions of partial reinforcement, factors other than UCS intensity might influence D or in some other way account for the level of eyelid conditioning performance.

Patterned Reinforcement Studies

Few studies have been undertaken comparing schedules of random partial reinforcement with a patterned schedule of reinforcement

such as single or double alternation. In those studies that have, the results have been conflicting. Grant, Riopelle, and Hake (1950) compared double alternation and random 50% reinforcement schedules and found superior acquisition to the random schedule. In a replication of this study, Hickok and Grant (1964) found double alternation to be superior. Hartman and Grant (1962) found no difference in performance between random and double alternation schedules and also observed that few Ss could verbally describe the double alternation schedule at the completion of the experiment. Further support for this latter finding has been given by Prokasy, Carlton, and Higgins (1967). They employed one random, two patterned (single and double alternation), and two nonrandom probabilistic schedules of partial reinforcement and found that with a single alternation or double alternation pattern of reinforcement some Ss responded to the pattern while others did not. Further analysis based on a linear operator model (Bush and Mosteller, 1951), which assumes that the tendency to make a response increases following a reinforced trial (UCS presented) and decreases following a nonreinforced trial (UCS omitted), indicated that for random and nonrandom probabilistic schedules response probability increases following a reinforced trial. This finding has been recently confirmed by Higgins and Prokasy (1968).

Beecroft (1966) has summarized the literature on patterned reinforcement in eyelid conditioning as follows:

> "At the moment it is easier to formulate what the findings of patterned reinforcement should be than to prove this to be the case. First, some schedules theoretically allow for differential responding on reinforced and nonreinforced trials whereas others, such as the traditional random reinforcement schedule, do not. Second, either perception of the schedule, or verbal information concerning it, can produce differential responding. Third, assuming that the perception or verbal information is accurate with respect to reinforcement sequence, there will be an increase in voluntary responding on reinforced trials and an inhibition of responding on nonreinforced trials. Fourth, whether or not a patterned schedule will produce more or fewer responses than a random schedule will depend on the combination of facilitating and inhibiting factors on reinforced and nonreinforced trials." (p. 130)

Alternative Theoretical Considerations

Spence's (1958) theory of generalized D has been useful in accounting for the effects of UCS intensity in continuously reinforced eyelid conditioning. The Ross and Spence (1960) study indicated that it was applicable to random partial reinforcement as well, although the relationship was not as simple. However, certain inconsistencies (Boice and Boice, 1966; Fowler, 1964; and Runquist, 1963) have appeared in the literature and it is possible that under certain conditions the theory may not be applicable. Other theories may be relevant, however, and the recent theoretical considerations of Prokasy (1965) and Rescorla (1967) might be particularly germane.

Prokasy (1965) considers the classical conditioning situation to be a special case of signal transmission in that two signals (the onset of the CS and the onset of the UCS) are generated over time. The S forms an association between the two signals and the likelihood of the occurrence of a response is determined by this

association. Similarly, Rescorla (1967) has suggested that the temporal contingency between CS and UCS rather than the number of CS-UCS pairings, which has previously been assumed to define conditioning, is the more relevant aspect in classical conditioning. Contingency has been defined by Rescorla as the degree of dependency which presentation of the UCS has upon prior presentation of the CS. Schedules of reinforcement in classical conditioning can thus be defined in terms of the probability of the UCS occurring given that the CS occurred at some designated prior time.

It is clear that both Prokasy and Rescorla are talking about the same thing. Prokasy's "association" is really a contingency relationship between two signals (CS onset and UCS onset) such that the UCS can be predicted to some specified degree by the occurrence of the CS. This type of contingency relationship can be considered as a classical contingency for it relates an environmental event (the occurrence of the CS) to UCS onset. The classical contingency should thus be affected by the relationship between CS and UCS onset. One method of manipulating this relationship is based on the type of reinforcement schedule used.

Theoretically, another contingency relationship also occurs in the classical conditioning paradigm which relates response contingencies to UCS offset. This type of relationship can be termed the instrumental contingency and is affected by parameters of the UCS. Because UCS onset must necessarily precede UCS offset the two contingencies are not independent. Theoretically,

factors which improve the contingency relationship between CS and UCS onset should also improve the effect of UCS parameters in determining the instrumental response to the CS.

Because of this relationship the classical contingency may determine the extent to which the UCS modifies the response. In effect, variations in UCS intensity should influence instrumental control of the response given that classical conditioning has occurred through the classical contingency.

Statement of the Problem

This study is designed to investigate the Prokasy-Rescorla notion of a distinct classical contingency operating in the classical conditioning paradigm and to show that UCS intensity operates, not by generalized drive, but through instrumental control of the response, given that classical conditioning has occurred through the classical contingency. These two contingencies, CS-UCS(onset) and R-UCS(offset), comprise the two-contingency model. This model predicts differing effects of UCS intensity; namely, differential instrumental control of the response for partial reinforcement schedules which vary the classical contingency. To vary this contingency different types of 50% partial reinforcement schedules can be employed. One is a double alternation (DA) schedule in which the probability of a UCS occurring following a CS would be 1.0 on reinforced trials (UCS presented) and 0.0 on nonreinforced trials (UCS omitted). Another schedule would be run-biased (RB) in which the probability of a UCS occurring following a CS would

be high (0.8) for one part of the experiment and low (0.2) for another part (this high-low probability shift must occur in order to equate number of reinforced trials with other schedules). A final partial reinforcement schedule would be a random (R) schedule in which the probability of a UCS occurring following a CS would be 0.5. In terms of the two-contingency model a strong UCS intensity (relative to a weak UCS intensity) should produce higher levels of conditioning for schedules of partial reinforcement with a rigid classical contingency. Such an effect would be expected for the DA schedule and the RB schedule. However, for a schedule where the classical contingency is more variable, such as the R schedule, the effectiveness of UCS intensity in instrumentally controlling the response should be reduced.

CHAPTER 2

Method

Design

Three 50% partial reinforcement schedules and two levels of unconditioned stimulus (UCS) intensity were employed as the independent variables in this study. The three 50% partial reinforcement schedules were designated double alternation (DA), run-biased (RB) and random (R). Each schedule of partial reinforcement consisted of 80 reinforced trials and 80 nonreinforced trials. A reinforced trial was defined as the presentation of a UCS 500 msec after the onset of a conditioned stimulus (CS) whereas a nonreinforced trial was defined as the presentation of the CS alone. Each partial reinforcement schedule began with a reinforced trial. A restriction on the R schedule was that 10 reinforced and 10 nonreinforced trials occurred in each block of 20 trials. The RB schedule consisted of 8 blocks of 20 trials. The probability of a reinforced trial in the RB schedule was 0.8 in blocks 1, 3, 5 and 7 and 0.2 in blocks 2, 4, 6 and 8. The probability of a nonreinforced trial was 0.2 in blocks 1, 3, 5 and 7 and 0.8 in blocks 2, 4, 6 and 8. The DA schedule consisted of a repeating sequence of two reinforced trials followed by two nonreinforced trials. Each schedule, therefore, had 20 reinforced and 20 nonreinforced trials for each block of 40 trials. Appendix A presents the precise sequence of reinforced

and nonreinforced trials for the three schedules. Thus, this study involved the use of six groups comprising a 2 x 3 factorial design in which a weak (50 mm) and a strong (150 mm) UCS intensity were made orthogonal to a DA, RB and R schedule of 50% partial reinforcement.

Subjects

The Ss were 187 University of Alberta students enrolled in the introductory psychology class who took part in the experiment to fulfill a course requirement. None had previously served in an eyelid conditioning experiment. Seven Ss were rejected: two because of experimenter error, four because of technical difficulty with the apparatus, and one because of illness during the experiment. The remaining 180 Ss were randomly assigned to one of the six conditions in order of appearance at the laboratory such that 15 males and 15 females were assigned to each condition.

Apparatus

The conditioning laboratory consisted of two separate rooms in Assiniboia Hall at the University of Alberta. One room contained the apparatus for the programming and presenting of stimuli and for the recording of responses. The other room, 12 ft x 13 ft, contained two 3 ft x 6 ft booths for Ss, arranged so that two Ss could be run simultaneously. The inside of each

booth was painted flat white and was illuminated by a separate 25 watt incandescent lamp located on the wall above and behind the S's head. The Ss were seated in office type wooden semi-contour armchairs equipped with rollers. Although the experimental room was relatively sound-proof, a Travel-Aire 830 Air Cooler was used to provide a constant background masking noise.

The CS appeared as an increase in brightness on a 3 in. x 5 in. milk glass screen with a narrow black border. This screen, located on the back wall of each booth at the seated S's eye level and approximately 4 ft from his eyes, was part of an IEE Model 80,000 digital display unit modified so that a translucent plexiglass filter was placed between the lamps in the display unit and the screen. When one of the lamps in the display unit was activated, the visual CS appeared as a diffuse light on the screen. Each S wore a pair of Telex HDP-53 A Earphones with foam ear cushions over which verbal instructions were presented. A microphone, located on the partition separating the booths, enabled the Ss to communicate with the experimenter as well as allowing the experimenter to monitor sounds in the experimental room.

The headsets for recording eyeblinks and presenting the UCS were the standard model marketed by the Hunter Manufacturing Company. They consisted of a microtorque potentiometer with the rotating armature connected to a false eyelash with a piece

of thread. The false eyelash was attached to the S's right upper eyelid by means of a piece of adhesive tape. Movements of the eyelid were recorded as resistance variation through the potentiometer. These movements were amplified and recorded with a two channel Brush Mark II ink writing oscillograph at a paper speed of 125 mm/sec. The UCS (compressed nitrogen) was delivered through an aluminum nozzle with a .5 mm orifice to the S's right cornea at a 45^{o} angle to his normal straight line of vision.

The apparatus for presenting and controlling stimuli was located in the room adjacent to the experimental room and was contained in a large relay rack along with the Brush recorder. A regulated Hewitt-Packard DC power source supplied a constant 10v low current through the potentiometer on the headset. This provided a resistance of approximately 1500 ohms with the eye open. Amplification was at .02 v/mm of pen movement with external adjustment of the pen being made by a bridge circuit. Timing of the CS and UCS durations and the CS-UCS interval was accomplished by two Hunter Model 111 Decade Interval Timers operating through a series of 24 vdc relays. A third Hunter Timer activated the Brush recorder prior to CS onset so that the paper was moving at maximum velocity for the entire CS-UCS interval. The stimuli were programmed with punched tape and selected by a Convair Tape Transmitter driven by a 12-rpm synchronous motor. The UCS duration was controlled by a 24 vdc solenoid valve and the intensity of the UCS was

regulated with a Hoke-Phoenix Model 804 pressure regulator. The compressed nitrogen (Commercial Grade G Level) was provided from a tank situated in the apparatus room with the pressure monitored by a pressure gauge and a mercury manometer.

The weak UCS intensity used in this study was sufficient to support a 50 mm column of mercury and the strong UCS intensity supported a 150 mm column of mercury. This corresponds approximately to 1.0 and 3.0 psi for purposes of comparison with other studies. The UCS was 75 msec in duration and followed the onset of the CS (on reinforced trials) by 500 msec. Both CS and UCS terminated simultaneously.

A conditioned response (CR) was defined as a deflection in the record greater than 1 mm in the interval 150-500 msec after CS onset.

Procedure

Either one or two Ss could be run during each experimental session. Upon arrival at the laboratory Ss were met by the experimenter and taken directly to the experimental room and seated in the armchairs. The experimenter explained to the Ss that a headset and earphones would be placed on their heads and that all necessary instructions would be formally given over the intercom system. Attaching the headset and connecting the potentiometer (via the false eyelash) to the S's eyelid took approximately two minutes per S. Upon completion of this task

the experimenter left the experimental room. Neutral instruction which mentioned that the Ss should respond naturally were read by the experimenter over the intercom system (Appendix B presents a copy of the instructions used). Conditioning trials followed immediately and were randomly spaced at 10-, 15-, and 20- sec intervals. Each experimental session lasted approximately 40 minutes.

Upon completion of the experimental session Ss were shown the room containing the apparatus and given a brief explanation of the nature of the experiment. Ss were cautioned not to reveal the details of the experiment to other introductory psychology students as these students were also eligible to serve in the experiment.

CHAPTER 3

Results

Figure 1 presents the conditioning curves for the three schedules of 50% partial reinforcement for each level of UCS intensity. Because 20 trials were required to equate the number of reinforced and nonreinforced trials in the DA and R conditions these curves reflect level of conditioning more than they do acquisition. The irregular curves of the RB conditions reflect the switch from a high percentage of reinforcement (80%) to a low percentage of reinforcement (20%) over these 20 trial blocks. It will be recalled that it took 40 trials to equate the number of reinforced and nonreinforced trials in this schedule. It is evident from these curves that the relative level of conditioning for the different schedules changes as a function of the intensity of the UCS.

Table 1 presents the results of an analysis of variance carried out as a 3 x 2 x 2 factorial design with the dependent variable being the number of CRs for each subject within each block of 40 trials. The effect of trials was significant but none of the interactions over trials were significant. Of major interest is the significant schedule x intensity interaction which is depicted in Figure 2. Both the RB and DA schedules reflect performance differences as a function of UCS intensity in the expected direction. That is, the stronger UCS intensity resulted in a higher level of

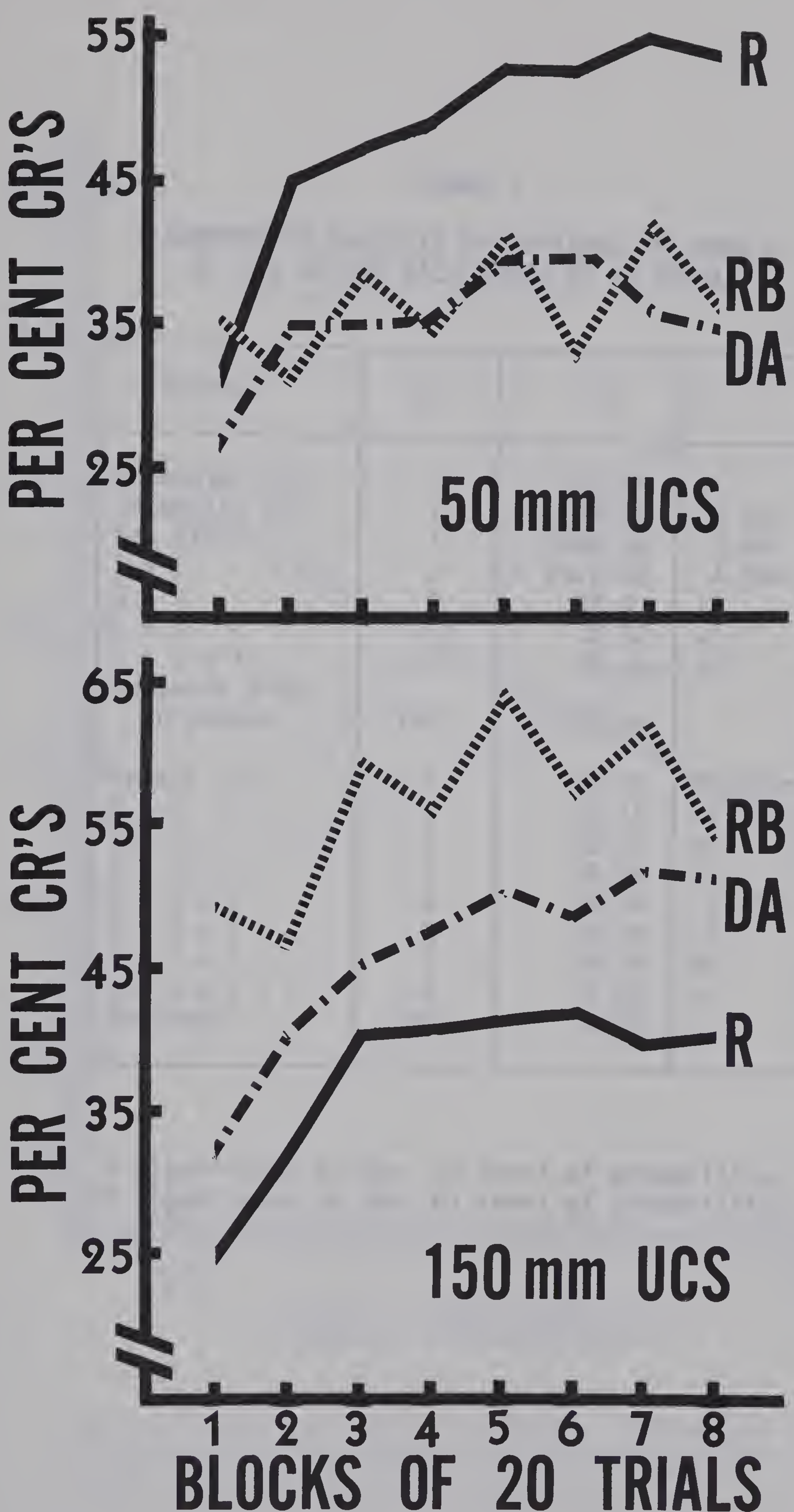

Figure 1: Per cent CR's for Double Alternation (DA), Run-biased (RB) and Random (R) schedules of partial reinforcement over blocks of 20 trials for each UCS intensity.

TABLE 1

SUMMARY OF ANALYSIS OF VARIANCE OF NUMBER OF CRs WITHIN EACH BLOCK OF 40 TRIALS

Source	df	MS	F
Schedule (S)	2	301.59	<1
Intensity (I)	1	1235.06	2.28
Sex (X)	1	1840.00	3.40
S x I	2	2376.22	4.39*
S x X	2	96.99	<1
I x X	1	32.52	<1
S x I x X	2	69.45	<1
Subjects within groups	168	541.60	
Trials (T)	3	779.75	25.92**
S x T	6	17.71	<1
I x T	3	25.37	<1
X x T	3	15.83	<1
S x I x T	6	38.44	1.28
S x X x T	6	10.94	<1
I x X x T	3	24.10	<1
S x I x X x T	6	12.82	<1
Residual	504	30.09	

* Significant at the .05 level of probability.
** Significant at the .01 level of probability.

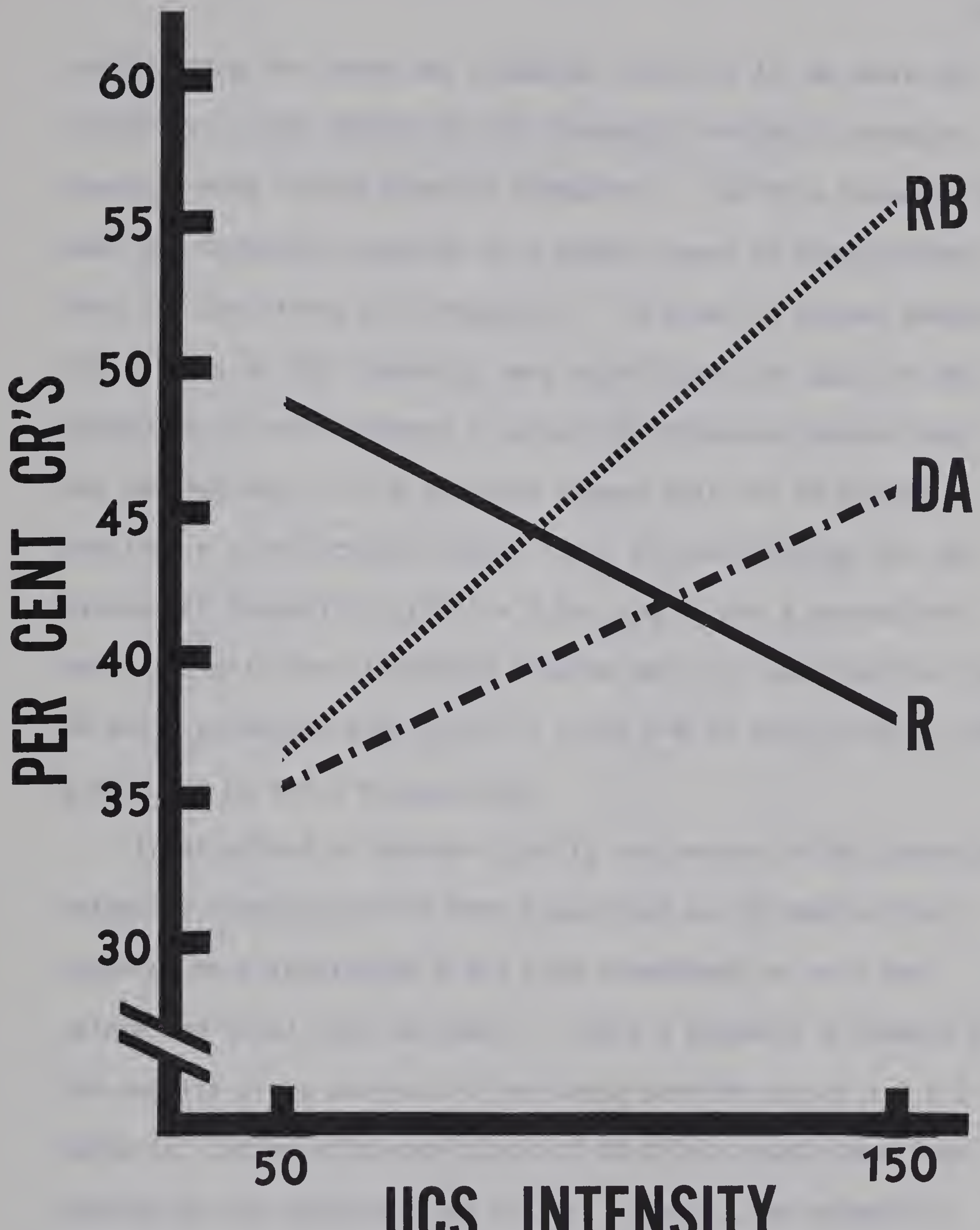

Figure 2: Per cent CR's for Double Alternation (DA), Run-biased (RB) and Random (R) schedules of partial reinforcement for each UCS intensity.

conditioning for these two schedules relative to the weak UCS intensity. The effects of UCS intensity for the R schedule, however, were in the opposite direction. For this schedule the weak UCS intensity resulted in a higher level of conditioning than did the strong UCS intensity. In order to assess whether the effects of UCS intensity were significant for each of the schedules of reinforcement a series of orthogonal comparisons was carried out. This analysis showed that the RB schedule attained a significantly higher level of conditioning for the strong UCS intensity, $t(174) = 2.64$, $p < .01$ for a one-tailed test. Significant intensity effects were not obtained for the DA and R schedules with $t(174) = 1.45$, $p < .10$ and $t(174) = -1.46$, $p < .10$ for DA and R respectively.

In an effort to further clarify the nature of the schedule x intensity interaction CRs were classified as to whether they occurred on a reinforced trial (UCS presented) or on a non-reinforced trial (UCS omitted). Table 2 presents a summary of the results of an analysis of variance carried out as a 3 x 2 factorial design with each block of 40 trials subdivided into reinforced and nonreinforced trials. Again, the schedule x intensity interaction was significant as was the effect of trials. None of the interactions over trials were significant. The reinforcement variable was significant as was the reinforcement x schedule interaction. Of major interest was the highly significant reinforcement x schedule x intensity interaction which

TABLE 2

SUMMARY OF ANALYSIS OF VARIANCE OF NUMBER OF CRs FOR REINFORCED AND NONREINFORCED TRIALS WITHIN EACH BLOCK OF 40 TRIALS

Source	df	MS	F
Schedule (S)	2	151.39	<1
Intensity (I)	1	633.35	2.37
S x I	2	1167.05	4.36*
Subjects within groups	174	267.72	
Trials (T)	3	386.51	36.85**
Reinforcement (R)	1	297.93	28.40**
T x R	3	13.37	1.27
T x S	6	8.40	<1
T x I	3	13.62	1.30
T x S x I	6	19.03	1.81
R x S	2	235.11	22.41**
R x I	1	29.76	2.84
R x S x I	2	56.44	5.38**
T x R x S	6	2.78	<1
T x R x I	3	2.82	<1
T x R x S x I	6	5.85	<1
Residual	1218	10.49	

* Significant at the .05 level of probability.
** Significant at the .01 level of probability.

is shown in Figure 3. Both DA and RB schedules reflect higher levels of conditioning on reinforced trials for both UCS intensities with the highest levels of conditioning being attained under the strong UCS intensity. No effects of this type were obtained for the R schedule. The R schedule reflects a higher level of conditioning for the weak UCS intensity. Furthermore, a slightly higher level of responding was obtained for nonreinforced trials under the strong UCS intensity. In terms of UCS intensity the effect of reinforcement was most pronounced for the DA schedule in that the highest level of conditioning was obtained on reinforced trials under the strong UCS intensity condition. To evaluate these effects a series of orthogonal comparisons was carried out on CRs occurring during reinforced trials with significant intensity effects being obtained for the DA schedule, $t(174) = 2.08$, $p < .05$, and for the RB schedule, $t(174) = 2.46$, $p < .01$, the strong intensity groups performing better in both cases. The comparison on the R schedule was not significant, $t(174) = -1.44$, $p < .10$. In terms of orthogonal comparisons on nonreinforced trials the strong UCS intensity level resulted in significantly better performance for the RB schedule, $t(174) = 2.64$, $p < .01$, but not for the DA schedule, $t(174) = .71$, $p > .10$, nor for the R schedule, $t(174) = -1.31$, $p < .10$.

Because no significant intensity effects were evidenced for the R schedule using a total trials or reinforced-nonreinforced trials type of analysis, it was thought that an analysis based on

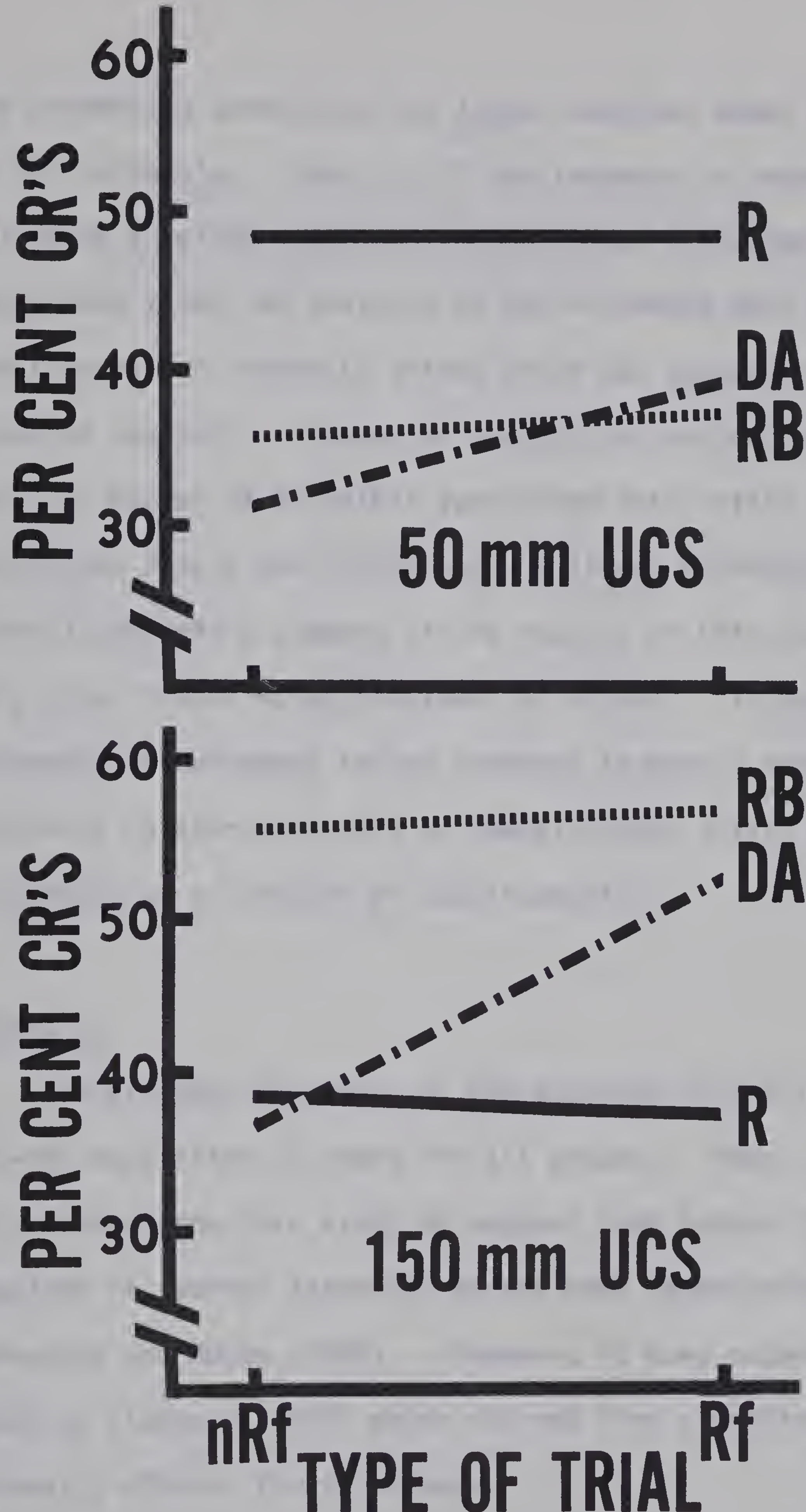

Figure 3: Per cent CR's for Double Alternation (DA), Run-biased (RB) and Random (R) schedules of partial reinforcement on nonreinforced (nRf) and reinforced (Rf) trials for each UCS intensity.

the assumption underlying the linear operator model might apply to this schedule. That is, if the tendency to respond increases following a reinforced trial and decreases following a non-reinforced trial, an analysis of CRs following each type of trial might reveal an intensity effect which was obscured in the other types of analysis. Hence, an analysis of variance was carried out with blocks of 40 trials subdivided into trials which followed reinforced trials and trials which followed nonreinforced trials. Table 3 presents a summary of the results of this analysis, the only significance being obtained for trials. It appears that no increment or decrement in the tendency to make a response on trials following reinforced trials or nonreinforced trials occurred in the R schedule as a function of UCS intensity.

Latencies

The greatest frequency of CRs occurred in the interval 350-400 msec after CS onset for all groups. Hence, there is no evidence from this study to suggest that higher UCS intensities resulted in shorter latencies as has been demonstrated by Gormezano and Moore (1962). However, it does support a recent study by Fishbein (1967) which did not find significant UCS intensity effects for CR latency.

TABLE 3

SUMMARY OF ANALYSIS OF VARIANCE OF CRs
FOR TRIALS FOLLOWING A REINFORCED TRIAL AND
TRIALS FOLLOWING A NONREINFORCED TRIAL WITHIN
EACH BLOCK OF 40 TRIALS FOR THE RANDOM SCHEDULE

Source	df	MS	F
Intensity (I)	1	550.40	2.40
Subjects within groups	58	229.77	
Trials (T)	3	172.21	15.57**
Trial Type (K)	1	19.21	1.74
I x T	3	10.91	<1
K x T	3	7.85	<1
I x K	1	2.12	<1
I x K x T	3	3.05	<1
Residual	406	11.06	

** Significant at the .01 level of probability.

CHAPTER 4

Discussion

The major findings of this study were:

(a) a schedule by intensity interaction reflected in both a total trials and reinforced-nonreinforced trials analysis;

(b) superior conditioning to the strong UCS intensity for the RB schedule but not for the R schedule;

(c) an intensity effect for the DA schedule on reinforced trials.

The intensity effect for the RB schedule was predicted by both the theory of generalized drive and the two-contingency model suggested here. In terms of the theory of generalized drive, the stronger UCS intensity leads to an increase in $\underline{r}_e$ and consequently $\underline{D}$, which is reflected as a function of the greater frequency of CRs in the strong UCS intensity condition. The two-contingency model predicted this result as well for if conditioning occurred through the classical [CS-UCS(onset)] contingency for this schedule (the probability is 0.80 that a reinforced or nonreinforced trial will occur) then the response should be modified by the instrumental contingency [R-UCS(offset)]. This prediction was supported since the strong UCS intensity resulted in the higher level of conditioning. Hence, for the RB schedule the Prokasy-Rescorla notion of conditioning occurring through the classical contingency is supported as well as the notion that UCS intensity acts through instrumental control of the response given that conditioning has occurred through the

classical contingency.

The two-contingency model predicted a stronger UCS intensity effect for the DA schedule relative to the RB schedule on the basis of a more rigid classical contingency. That is, the UCS is more predictable given the sequence of trials in the DA schedule than it is in the RB schedule. This was not the case, however, since the prediction made by the two-contingency model did not allow for differential responding to the reinforced and nonreinforced trials for this schedule. The analysis which was carried out with the effects of reinforced and nonreinforced trials separated revealed this to be an important factor. Significant UCS intensity effects were obtained for the DA schedule on reinforced trials but not on nonreinforced trials, with the stronger UCS intensity resulting in a higher level of conditioning than the weaker UCS intensity. The Ss appear to abstract the crucial aspects of the schedule (which trials had a UCS associated with a CS) and respond differentially to these trials relative to the nonreinforced trials. The instrumental contingency then acts to control the response more effectively on these trials because classical conditioning has, as a consequence of the predictable CS-UCS(onset) contingency, resulted in differentiation between trials.

No significant difference was obtained for intensity effects with the R schedule. In fact, the stronger UCS intensity resulted in a lower level of conditioning than did the weak UCS intensity, an effect predicted neither by the theory of generalized drive nor by the two-contingency model proposed here. This inverse effect has

been noted before by Runquist (1963) where it was not significant and by Boice and Boice (1966) where the effect was just barely significant. It appears that this inverse effect might be somewhat transient and that further research varying other instrumental contingencies, such as [R-UCS(onset)], is required to clarify the reasons for this inversion.

In terms of latencies, no differences were obtained as the highest frequency of CRs occurred in the interval 350-400 msec after CS onset for all groups. Thus, latencies do not appear to be an index reflecting UCS intensity effects as has been found by Gormezano and Moore (1962), at least for the interstimulus interval employed in this study.

Because of the schedule x intensity interaction little can be said about the effects of the three reinforcement schedules independent of UCS intensity. With the weak UCS intensity level the DA and RB groups performed about equally with the R group resulting in the highest level of conditioning. This finding corresponds with that of Grant, Riopelle and Hake (1950). This was not true with the strong UCS intensity level. Here the RB group performed best followed by DA and then the R groups. The two-contingency theory predicted that the DA group would result in a higher level of performance than the RB group for the strong UCS intensity because of the more predictable classical contingency but, as was pointed out, response differentiation to reinforced and nonreinforced trials had not been taken into account when the theory

was formulated. An alternative explanation is that the RB group established and maintained a higher level of performance because it received six more reinforced trials (UCS presented) in the first block of 20 trials than did the DA group. That reinforced trials are important in determining level of performance has been pointed out by Spence, Haggard, and Ross (1958). This factor probably accounts for the RB group maintaining a higher level of conditioning relative to the DA group. The low level of conditioning performance of the R group is interpreted as reflecting the lack of instrumental control of the response since a lesser degree of classical conditioning occurred as a result of the unpredictable (chance level) classical contingency.

Under certain conditions, such as the R schedule, where the contingency relationship predicting the occurrence of the UCS from the CS is only at chance level, the effects of UCS intensity do not appear to influence conditioning in the usual way. That is, for the R schedule, the strong UCS intensity did not lead to a higher level of conditioning relative to the weak UCS intensity. As the theory of generalized drive is presently formulated, it cannot handle this phenomenon. That factors other than generalized drive may operate in a random schedule of reinforcement has been pointed out in a recent study by Spence and Platt (1967). These authors suggest that a factor such as a cognitive inhibitory set "not to respond", which is assumed to be operative with nonreinforcement in partial reinforcement studies,

can be virtually eliminated in a situation where the S is presumably unaware that he is being conditioned (Spence, 1963). Hence, if the theory of generalized drive can be modified by taking cognitive factors into account, this theory might be able to explain the results of this study.

The two-contingency model of classical conditioning which is presented here is useful in interpreting the results of this study. However, it is evident that further research and possible modifications to the theory are necessary to explain why the strong UCS intensity R group performed at a lower level than did the weak UCS intensity R group, even though this difference was not significant. The fact that different schedules of 50% partial reinforcement interact with UCS intensity in human eyelid conditioning supports the Prokasy-Rescorla notion of a classical contingency which determines the degree to which conditioning occurs. This interaction also supports the notion that the effects of UCS intensity are due to instrumental control of the response given that conditioning has occurred as a result of the classical contingency. That UCS intensity effects are entirely due to the level of D produced to emotional responses, as Spence's theory of generalized drive assumes, is questionable.

The two-contingency model of the traditional classical conditioning paradigm could be tested in other ways. One line of research which has been suggested by the outcome of this study is to vary the

ISI under different intensity levels in the context of continuous reinforcement. Essentially, if the ISI is variable from trial to trial, the dependency of the CR on the UCS should be reduced and consequently so should the effects of UCS intensity.

In conclusion, the theory of generalized drive, as currently formulated, does not account for the differing effects of UCS intensity on the varying types of 50% partial reinforcement schedules which occurred in this study. The two-contingency model, which postulates that UCS intensity modifies the response through an instrumental contingency given that conditioning has occurred through the classical contingency, can be applied to account for these results.

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Appendix A

Schedules of 50% Partial Reinforcement

(R) denotes a reinforced trial. That is, the UCS was presented 500 msec after CS onset on this type of trial. (N) denotes a nonreinforced trial (UCS omitted).

Double alternation schedule: sequence repeated 40 times.

R R N N

Run-biased schedule: sequence repeated twice.

R R N R R R N R R R R R N R R R R R N R

N N N N R N N N N R N N N R N N N R N N

R N R R R R R N R R R N R R R R N R R R

N N N R N N N N N R N R N N N N R N N N

Random schedule: sequence repeated twice.

R N N R N R N R R N N N R N R R R N N R

N R R N N R N N R R N R R N R N R N N R

N R N N N R N R R R N R N R R N N R N R

R N R N N R N R R N N N R N N R R N R R

Appendix B

Instructions to Subjects

Please listen carefully to the following instructions and follow them to the best of your ability. We cannot tell you the purpose of the experiment at this time except that we wish to measure your reactions to different types of stimuli. Remain seated as quietly as possible and keep looking at the black box on the wall in front of you. Do not touch anything on your head and do not communicate with one another. You will receive a series of stimuli during the experiment consisting of a light from the box and a puff of air. It is extremely important that you do not try to control any of your natural reactions to these stimuli. Just remain as relaxed as possible and let your reactions take care of themselves. You can communicate with me at any time by speaking up clearly. Is this clear? Please tell me what you are to do.